

VIRGINIA DEPARTMENT OF TRANSPORTATION
TRAFFIC ENGINEERING DIVISION
INSTRUCTIONAL & INFORMATIONAL MEMORANDUM

GENERAL SUBJECT: Barrier Systems	NUMBER: IIM-TE-366.4
	SUPERSEDES: TE-366.3
SPECIFIC SUBJECT: Guardrail System Upgrade: Functional Condition Ratings and Upgrading Strategies for Existing Guardrail Systems	DATE: April 9, 2019
	SUNSET DATE: None
APPROVAL: /original signed by/ Raymond J. Khoury, P.E. State Traffic Engineer Richmond, VA April 9, 2019	

Changes are shaded

CURRENT REVISION

This memorandum was revised to include updates based on VDOT adoption of "Manual for Assessing Safety Hardware" (MASH) performance criteria. Organizational improvements were also made.

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PURPOSE AND NEED

The term “guardrail systems” refers to typical guardrail sections such as W-Beam and cable barriers, transition areas, and guardrail end treatments. Guardrail systems are an important roadside safety feature. To help to ensure they perform their intended functions, periodic reviews of in-service guardrail systems for timely upgrade and repair are necessary.

This memorandum provides guidance to determine the functional condition ratings and evaluate site condition location ratings of existing guardrail systems as part of the agency’s maintenance and operations program. This policy may also be used to evaluate existing guardrail under other agency programs, such as the construction and land use programs.

This memorandum is not intended to be the sole source of direction for specific guardrail improvement prioritization; however, general replacement strategies are recommended. For situations where more specific policy or guidance are not provided, guardrail with functional condition ratings of Grade B, C, or D should be programmed for upgrade to meet current standard or Grade A condition.

As described in the figure below, the guardrail functional condition and site location condition evaluation ratings are designed to measure the functionality of guardrail systems compared with the current FHWA/VDOT standards.

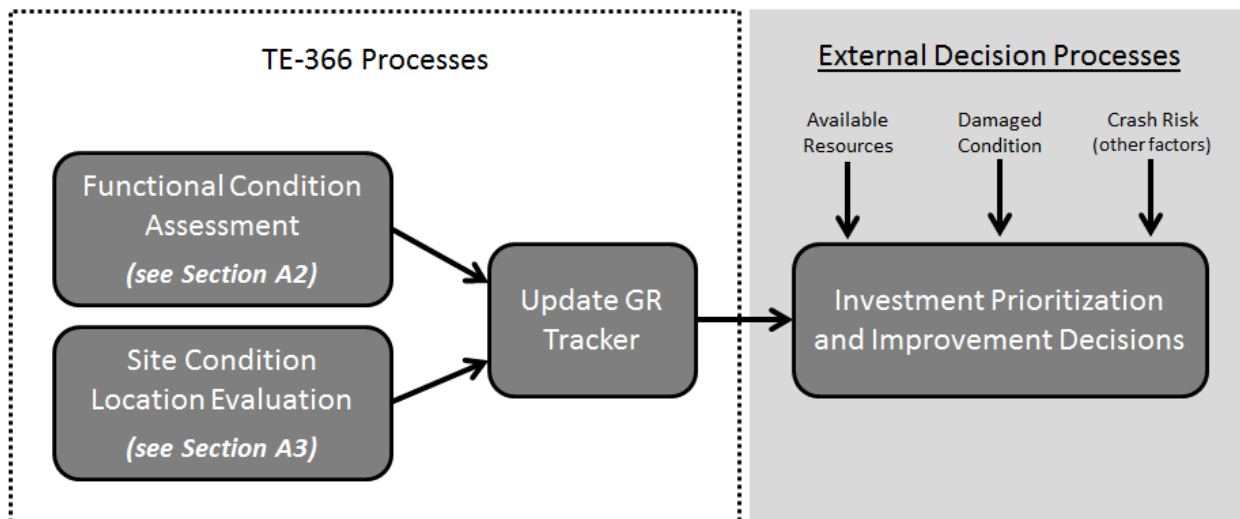


Figure 1 – TE-366 Process and Relation to Investment Prioritization and Improvement Decisions

The approach specified by this policy requires a user to complete an assessment of each of the three primary components of the guardrail system (the run-on terminal, run-off terminal, and rail) as well as an evaluation of site conditions which may impact guardrail performance. A detailed methodology is provided for the establishment of component-specific and overall guardrail functional condition ratings based on detailed measurements and observations taken during guardrail functional condition evaluation.

Protocol for the documentation and summary of site conditions effecting guardrail performance are also provided. These evaluations are provided independently from the guardrail functional condition rating as they are not specific to the existing guardrail system itself.

Personnel responsible for assigning guardrail functional condition and site condition location evaluation ratings in accordance with this document **shall** have successfully completed VDOT's Guardrail Installation Training (GRIT) course and hold a current certification.

The functional condition ratings of guardrail systems **shall** be used to determine the severity of the problem, level of necessary upgrade, and timelines to assist in prioritizing investment decisions. The ratings are to be used to determine the level of upgrade and recommended improvement timelines to guide investment decisions.

Guardrail systems are roadside safety features designed to redirect errant vehicles from a dangerous path. Because guardrail systems are potential hazards themselves, they **shall** only be used when it is necessary to shield vehicles from a more hazardous condition. If the hazard is no longer present or no longer deemed a hazard at the site, the installation should be scheduled for removal.

RELATED POLICY GUIDANCE

This memo is to be used in conjunction with [TE Memo-367](#), which provides condition ratings and spot-repair strategies for damaged guardrail systems and end treatments as part of the "Hits Repair" program. Functional condition ratings of the entire run of damaged guardrail **shall** be determined prior to assessing the damage condition rating of guardrail systems. Refer to the Virginia Department of Transportation Fiscal Division District Generated Receivables Procedures, Number: PM-FD-2015-06 for guidance on cost-recovery options.

Refer to [Appendix I](#) and [Appendix J](#) of the [VDOT Road Design Manual](#) for guidance and guidelines on design upgrading existing guardrail systems, associated with construction and major rehabilitation projects. Refer to the [VDOT Guardrail Installation Training \(GRIT\) Manual](#) for general information on the installation, replacement and repair of guardrail systems. All new guardrail installations **shall** comply with current [VDOT Road and Bridge Standards](#) and [VDOT Road and Bridge Specifications](#).

A system methodology to periodically collect physical inventory information and functional condition information will be established under a separate guidance.

DEFINITIONS

For the purpose of this policy, following are the definitions of the various guardrail components referred to throughout this TE Memorandum:

Guardrail Section: Individual segment of guardrail with a consistent cross section such as:

- End treatment
- Transition area, or
- W-beam, cable, or other segments (which could include multiple manufactured panels which together make one guardrail section)

Guardrail Run: A continuous length of guardrail excluding the end treatments.

Guardrail System: A complete functional guardrail in its entirety, including all guardrail sections, cables, beams, posts, block-outs, and hardware.

End Treatment: The terminal section at either end of a guardrail run. Classified as either run-on or run-off.

ATTACHMENT A: Functional Conditions of Guardrail Systems

Section A1 below is informational only and describes the general description of the four categories of condition rating. Subsequently, Section A2 provides more detailed criteria for each guardrail system type.

Section A1 – Guidance on Guardrail Functional Condition Ratings

Functional conditions of guardrail systems should be evaluated based on a windshield review or detailed guardrail assessment. All evaluated functional condition information (inventory, assessment, and recommended improvements) **shall** be collected and stored in the VDOT Guardrail Tracker Database (GR Tracker). The GR Tracker will help determine where to apply investments.

A1.1 – VDOT Guardrail Functional Condition Ratings

Grade A: Guardrail system is evaluated to be fully functional and capable of providing protection as intended. The guardrail system meets applicable VDOT standards, specifications, and policies based on field observations and measurements of rail heights.

Grade B: Guardrail system is evaluated to be adequately functional under a majority of impacts but may not meet all current VDOT standards.

Grade C: Guardrail system is evaluated to provide some protection for errant vehicles but does not comply with current VDOT standards.

Grade D: Guardrail system is evaluated to provide little protection for the errant vehicles. The guardrail system products that are not listed on the [VDOT NCHRP-350 Approved Products](#) or [VDOT Provisionally Approved MASH Products](#) lists **shall** be assigned a Grade D when evaluated against VDOT standards.

A1.2 General Criteria for Overall Guardrail Rating

A guardrail standard section and a guardrail end treatment **shall** be evaluated for the characteristics described in each attachment of this memorandum, as applicable. Detailed guidance on each characteristic is provided in the referenced section of this policy in the rightmost column of the table(s).

In the case where a guardrail run includes more than one standard section type of guardrail, each standard section type **shall** first be evaluated independently, and the overall standard section **shall** be rated no higher than the lowest Functional Condition of the multiple type(s).

If the guardrail run and end terminal(s) have different functional condition ratings, the overall guardrail system rating **shall** be rated based on the lowest Functional Condition as per the applicable table(s) included in the attachments.

These ratings shall be recorded into the VDOT GR Tracker.

A1.3 Upgrade Strategies and Timelines

The general upgrading strategies for the following substandard guardrail systems are included in Attachment D. Users should use engineering judgment to provide the best upgrade strategies for each specific situation.

Recommended guardrail improvements resulting from evaluation of VDOT maintained roadways shall be recorded into to the VDOT GR Tracker. A benefit factor will be assigned based on the guardrails' condition, crash risk, and pavement conditions and entered into the Traffic Engineering Division's Strategic Guardrail Program Prioritization system.

For guardrail upgrades in paving projects, refer to the latest version of VDOT Safety Analysis Guidelines for Paving Projects to determine the required timeline.

For guardrail repair projects, refer to the contract to determine the required timeline.

For projects outside of the maintenance and operational program, it is recommended that any guardrail systems that are impacted by the project and are rated in functional condition Grade B, C, or D are upgraded or repaired as part of the project.

Section A2 – Evaluating Functional Conditions of Guardrail Systems

Detailed guidance on guardrail system evaluation is provided in the VDOT GRIT Manual, the VDOT Road and Bridge Standards, VDOT Road and Bridge Specifications, and Appendix I and Appendix J of the VDOT Road Design Manual. The following provides key elements of the guidance related to guardrail system evaluation.

Note: during functional condition evaluation, guardrail inventory and condition information shall be recorded into the VDOT GR Tracker.

A2.1 Field Scope Evaluation

Field scope evaluation **should** be conducted to evaluate the functional conditions of guardrail systems. The evaluation **shall** be performed by VDOT GRIT-certified personnel. At a minimum, the inspector **shall**:

General

- Check guardrail warrants in the GRIT Manual are appropriately applied. Evaluate whether the existing guardrail meets guardrail warrants or if the existing guardrail can be eliminated at the specified location, and identify potential needs for new guardrail
- When applicable, check guardrail height for compliance with current VDOT standards
- Assess guardrail and terminals for compliance with current MASH/NCHRP-350 and VDOT standards and specifications
- Check if there are any fixed objects within the deflection area

Block-Outs and Hardware

- When applicable, check all block-outs for proper material, size, and position
- Check all hardware for tightness, proper size, and cable tension
- Check if weathering steel is present

Site Preparation, Shoulder Area, and Length of Need

- Determine if the Length of Need (LON) is in accordance with GRIT Manual
- Check the shoulder and area beneath the guardrail for excessive erosion
- Check the shoulder width behind the posts to ensure proper support of the posts

Curb and Transitions

- Check guardrail location relative to any curb
- Where applicable, check if systems are properly transitioned
- Note height and type of curb

Damage and Visible Defects

- Examine guardrail or cable for any signs of rust, damage, and deterioration
- Identify other obvious defects of guardrail and end treatments to be fixed
- Check all timber and steel posts for visible damage, rot, and/or insect infestation
- Check steel posts for rust, bends, or deflection

End Treatments

- Identify VDOT terminal standard/product and where applicable, manufacturer and model number
- Check height of rail elements or top cable
- Measure length of terminal
- Establish location and type of first post compared to manufacturer standard
- Where applicable, evaluate the condition of breakaway posts, extruder assembly, reflective sheeting, and cable anchorage. Cable anchorage tension should be addressed through maintenance.

The inspector can be directed to conduct additional work as required by VDOT engineers.

A2.2 Measuring the Height of Guardrail Section

The height of the cables or W-Beam rail elements is critical for the proper performance of the guardrail system. The cables or W-Beam rail elements must contact the design vehicle bumper at the correct position in order to prevent vaulting over or running under the guardrail system.

It is important that the appropriate technique or method is used to measure the height of the cable/rail elements. The location of the guardrail system relative to the slope beneath the cable/W-Beam rail element will determine how the height of the guardrail is measured. The guidelines for the standard guardrail systems listed below **shall** be used when measuring the height of respective guardrail systems. The ground profile grade for these systems must be a 6:1 or flatter slope.

The Functional Condition Ratings included in Attachment B and Attachment C only apply to evaluating existing guardrail systems based on existing site conditions (such as current pavement elevations). If the assessment is part of a planned pavement overlay, then the anticipated overlay thickness and resulting guardrail height must be taken into consideration during the assessment of the guardrail system's functional condition rating.

IIM-TE-366.4 – Attachment A

Functional Conditions of Guardrail Systems

The guardrail will be given the functional condition where 60% of guardrail heights fall within that functional condition category. For a detailed guardrail evaluation, a minimum of three (3) measurements is required for each guardrail section; additional measurements should be taken as needed based on the length of each section, with a maximum of twenty (20) measurements taken on a single guardrail section.

For a windshield guardrail review, height measurements are not required. Note: this is not applicable for construction projects.

The guardrail height is measured from different locations depending on the guardrail system. All W-Beam guardrail system will take the following features into account when determining the guardrail height:

- No system should be placed between 2' and 12' from the shoulder hinge point on a slope steeper than 10:1.
- If the face of the W-Beam is above a 10:1 or flatter surface, measure the height from the ground directly below the face of the W-Beam.
- If the W-Beam rail is 12' or more from the shoulder hinge point, measure guardrail height from the ground directly below the face of the rail.
- Where grading is steeper than 10:1, but not steeper than 6:1, and the W-Beam is within 2' of the shoulder hinge point (see Figure A1), the height is measured from the shoulder slope extended.

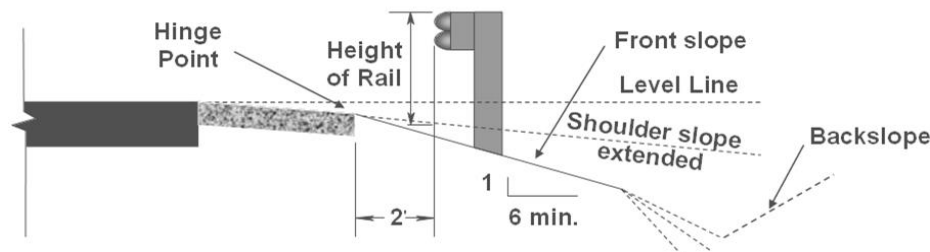


Figure A1 – Measuring the Height of Guardrail Systems; Grading Between 10:1 and 6:1, Rail Within 2' of the Shoulder

A2.2.1 – MASH Systems

For Standard GR-MGS1 the height is measured at the post.

Where combination curb and gutter is used, the height of the guardrail **shall** be measured from the projected pavement elevation at the face of curb. The height of the guardrail **shall** be measured at the face of curb from the pavement surface when gutter pan is not used.

A2.2.2 – NCHRP-350 W-Beam Systems

For Standard GR-2 and GR-8 the height is measured at the posts with a splice. For transitions between systems measure the height at the posts at the beginning and end of the transition between standard section lengths.

IIM-TE-366.4 – Attachment A

Functional Conditions of Guardrail Systems

The guardrail height, when placed flush with a curb, is measured from the roadway surface beneath the face of the W-Beam rail (flow line of curb). When offset from the curb, it is measured from the ground underneath the rail.

A2.2.3 – NCHRP-350 Cable Guardrail Systems

For Standard GR-3 cable systems the height of the cable system is measured at the posts. For GR-3 cable systems installed on 6:1 or flatter surface, the height **shall** be measured from the ground directly below the cable.

For proprietary systems follow the manufacturer's instructions to determine height.

A2.3 Deflection Distance

Guardrail systems are designed to absorb energy during a vehicle impact. This is accomplished by the guardrail's ability to deflect upon impact. Maximum dynamic deflection distance **shall** be measured as described for each guardrail system. No rigid or semi-rigid objects (hazards) **shall** exist within the deflection distance of any guardrail system.

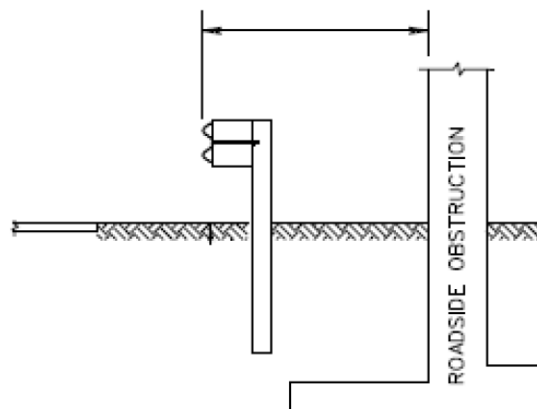
If fixed objects are found within the guardrail deflection distance, the fixed objects should be relocated outside the guardrail's deflection area when practical. If the fixed objects cannot be relocated, the guardrail should either be upgraded with a stiffer system or moved closer to the travel way to meet deflection requirements.

The guardrail deflection distance is measured from different locations depending on the guardrail system. The procedure for measuring deflection distance and maximum deflection distances are as follows:

A2.3.1 – MASH Systems

The maximum dynamic deflection distance for MASH W-Beam guardrail systems **shall** be measured from the **front of the W-Beam rail**, as shown in Figure A2. No rigid or semi-rigid objects (hazards) **shall** exist within the deflection distance shown in Table A1.

In order to reduce the deflection distance for Standard GR-MGS1 guardrail, the post spacing **shall** be reduced using Standard GR-MGS1A. Double-nesting the rail and installing rail along the back-side of posts **shall not** be permitted.



IIM-TE-366.4 – Attachment A

Functional Conditions of Guardrail Systems

Figure A2 – MASH W-Beam Guardrail System Deflection Distance

Table A1 – MASH W-Beam Guardrail System Maximum Deflection Distance

MASH W-Beam Guardrail System	Maximum Deflection Distance (ft)
GR-MGS1	5
GR-MGS1A	4

(Source: VDOT Road and Bridge Standards. This table is provided for convenience and is current as of May 2017. Any subsequent revisions to the VDOT Road and Bridge Standards override the values provided in this table.)

A2.3.2 – NCHRP-350 Systems

The maximum dynamic deflection distance for NCHRP-350 guardrail systems **shall** be measured from the **back of guardrail posts**, as shown in Figure A3. No rigid or semi-rigid objects (hazards) **shall** exist within the deflection distance shown in Table A2.

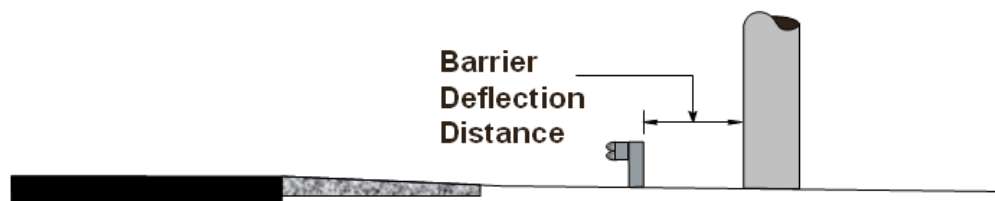


Figure A3 – NCHRP-350 Guardrail Systems Deflection Distance

Table A2 – NCHRP-350 Guardrail Systems Maximum Deflection Distance

NCHRP-350 Guardrail System	Maximum Deflection Distance (ft)
W-Beam Systems	
GR-2	3
GR-2A	2
Nested/Stiffened GR-2	2
GR-8	7
GR-8A	5
GR-8B	4
GR-8C	4.5
Cable Systems	
GR-3	11
Proprietary High Tension	Refer to Manufacturer's Specifications

(Source: VDOT Road and Bridge Standards. This table is provided for convenience and is current as of May 2017. Any subsequent revisions to the VDOT Road and Bridge Standards override the values provided in this table.)

A2.4 Curb Use with Guardrail

Detailed guidance on guardrail systems installed with curb is provided in the VDOT GRIT Manual, VDOT Road and Bridge Standards, and Appendix I and Appendix J of the VDOT Road Design Manual.

There are currently no terminals approved for use in conjunction with curbs. Existing guardrail terminals installed with curb should be identified and evaluated on a case-by-case basis to see if site conditions allow these guardrail terminals to be brought up to standard based on strategies discussed in the VDOT GRIT Manual and Appendix J of the Road Design Manual. Maximum functional condition ratings for guardrail systems installed with curb can be found in the Functional Condition Rating tables included herein.

A2.5 Weathering Steel (COR-TEN or ASTM A588) W-Beam Guardrail

Except in rare situations, weathering steel guardrail and end terminals are no longer acceptable for use due to the potential for premature material failure from excessive rust. Unless otherwise noted, weathering steel guardrail systems **shall** be upgraded to galvanized steel guardrail according to the current VDOT standards.

In rare situations where roadside barriers are required in areas where aesthetics are a primary concern, VDOT may utilize powder coated galvanized steel guardrail. This includes W-Beam, posts, terminals, fixed object attachments, and all hardware. **The use of powder coated galvanized steel guardrail shall be limited and must be approved by the District Traffic Engineer.** The installed guardrail system should be earth-tone in color. The Special Provision for Powder Coated Galvanized Guardrail can be obtained from the VDOT Materials or Scheduling and Contract Divisions.

There are two exceptions that allow the use of weathering steel:

- Weathering steel may be used on the backside of the Steel Backed Timber rails and for the posts and hardware used with them, as the steel thickness of Steel Backed Timber rails is significantly greater than on the typical 12-gauge W-Beam section. The Steel Backed Timber Guardrail is a special design and additional information is available from the Standards/Special Design Section of the VDOT Location and Design Division.
- Weathering steel systems (W-Beam, posts, and hardware) may be used if requested by an agency outside of VDOT. However, the agency must agree, through a Memorandum of Agreement, to maintain the installation by implementing a rigorous inspection and replacement schedule as referenced in the FHWA Memorandum [Roadside Design: Steel Strong Post W-Beam Guardrail](#).

Section A3 - Site Location Condition Evaluation

Existing guardrail systems should be evaluated for site preparation, length of need, and soil backing for compliance with current FHWA/VDOT requirements. Each location should be assigned an assessment based on the site's existing conditions compared to current VDOT requirements as well as to what extent improvements would be needed at the site location if current VDOT requirements are not met. The site condition evaluation **shall not** impact the Functional Condition Rating of the guardrail system. Further details of each rating are provided below:

IIM-TE-366.4 – Attachment A

Functional Conditions of Guardrail Systems

- **Meets current VDOT requirements:** The guardrail site location system meets current FHWA/VDOT standards, specifications, and policy.
- **Minor Improvement:** The site location is evaluated to be in need of modest site preparation, guardrail extension, and/or shoulder restoration to be compliant with current FHWA/VDOT requirements when upgrading the guardrail run. For example, a minor improvement up to 4 inches of stone/aggregate will be required to provide shoulder slopes and widths in accordance with VDOT standards.
- **Moderate Improvement:** The site location is evaluated to be in need of significant site preparation, guardrail extension, and/or shoulder restoration to be compliant with current FHWA/VDOT requirements when upgrading the guardrail run. For example, a moderate improvement is required if placement of surplus fill-material, in addition to stone/aggregate, will be necessary to provide shoulder slopes and widths in accordance with VDOT standards.
- **Major Improvement:** The site location is evaluated to be in need of substantial site preparation, guardrail extension, and/or shoulder restoration to be compliant with current FHWA/VDOT requirements when upgrading the guardrail run. For example, a major improvement will be required if additional engineering is likely necessary for preparation of minimum-plan straight-line diagrams with associated quantities and pay-items to address site preparation requirements.
- **Not Feasible:** The site location is not able to be modified when upgrading the guardrail run, or it is not feasible to fully assess the site location (i.e., embedded post length cannot be measured).

A3.1 – Site Preparation

It is desirable that guardrail systems be installed on flat terrain as shown in the Road and Bridge Standards. Grading in front of the terminal, in advance of the terminal, behind the end post, behind the terminal downstream of the end post, and above the finish grade of the stub protrusion should be as described in Section 4-D of the VDOT GRIT Manual and as shown in the VDOT Road and Bridge Standards. The Site Location Condition Evaluation thresholds for site preparation are described below. Refer to the VDOT Road and Bridge Standards for additional information for each terminal type.

For the Site Location Condition Evaluation, it is important to understand the required site preparation. The method for determining the required site preparation is summarized in the following sections. This information is necessary to gather during the Site Condition Evaluation and important to record in the GR Tracker for future prioritization and cost estimation, but the information is not used to assign a functional condition rating.

A3.1.1 – GR-7

- If the existing location **meets current VDOT requirements** for site preparation shown on Standard Sheet 501.13 for the GR-7 system, the site is considered to meet current standards and the end treatment can be replaced in kind at the same location without the need for additional site preparation work.
- If the existing location does not meet the site preparation requirements shown on Standard Sheet 501.13 for the GR-7 system and the level of site preparation necessary to meet that standard is considered **minor, moderate, major, or not feasible** per Section A3. Refer to AASHTO Roadside Design Guide Section 8.3.3.2

“Adjacent Grading.” If AASHTO Roadside Design Guide Section 8.3.3.2 is found to be applicable and the existing site complies with the guidance provided there in, the end section can be replaced without the need for additional site preparation work. If AASHTO Roadside Design Guide Section 8.3.3.2 is found not to be applicable, the end section cannot be replaced without the need for additional site preparation work.

A3.1.2 – GR-9

- If the existing location **meets current VDOT requirements** for site preparation shown on Standard Sheet 501.17 for the GR-9 system, the site is considered to meet current standards and the end treatment can be replaced in kind at the same location without the need for additional site preparation work.
- If the existing location does not meet the site preparation requirements shown on Standard Sheet 501.17 for the GR-9 system and the level of site preparation necessary to meet that standard is considered **minor, moderate, major, or not feasible** per Section A3. Refer to AASHTO Roadside Design Guide Section 8.3.3.2 “Adjacent Grading.” If AASHTO Roadside Design Guide Section 8.3.3.2 is found to be applicable and the existing site complies with the guidance provided there in, the end section can be replaced without the need for additional site preparation work. If AASHTO Roadside Design Guide Section 8.3.3.2 is found not to be applicable, the end section cannot be replaced without the need for additional site preparation work.

A3.1.3 – GR-MGS2

- If the existing location **meets current VDOT requirements** for site preparation shown on Standard Sheet 506.07 for the GR-MGS2 system, the site is considered to meet current standards and the end treatment can be replaced in kind at the same location without the need for additional site preparation work.
- If the existing location does not meet the site preparation requirements shown on Standard Sheet 506.07 for the GR-MGS2 system, refer to “Limited Use Site Preparation Requirements For GR-MGS2” shown on Standard Sheet 506.08.
 - If the site location condition is evaluated to be the same level for the 6’ site preparation shown on Standard Sheet 506.07 and the 4’ site preparation shown on Standard Sheet 506.08 and the work required falls within the project scope the end section cannot be replaced without additional site preparation work. The site should be upgraded to meet the 6’ site preparation standard shown on Standard Sheet 506.07.
 - If the site location condition is evaluated to be different levels to meet the 6’ site preparation shown on Standard Sheet 506.07 and the 4’ site preparation shown on Standard Sheet 506.08 and the work required to meet the 4’ site preparation falls within the project scope the end section cannot be replaced without additional site preparation work. The site should be upgraded to meet the 4’ site preparation standard shown on Standard Sheet 506.08.
 - If achieving the 6’ site preparation shown on Standard Sheet 506.07 or the 4’ site preparation shown on Standard Sheet 506.08 is not within the project scope, refer to AASHTO Roadside Design Guide Section 8.3.3.2 “Adjacent

IIM-TE-366.4 – Attachment A

Functional Conditions of Guardrail Systems

Grading.” If AASHTO Roadside Design Guide Section 8.3.3.2 is found to be applicable and the existing site complies with the guidance provided there in, the end section can be replaced without the need for additional site preparation work. If AASHTO Roadside Design Guide Section 8.3.3.2 is found not to be applicable, the end section cannot be replaced without the need for additional site preparation work.

A3.2 – Soil Backing

Full engagement of the guardrail post with the surrounding soil directly affects the performance of the guardrail system. Therefore, the distance to the end of the competent soil backing behind the guardrail **shall** be measured to assess the condition of the system.

For MASH systems, on a 10:1 or flatter slope, a minimum distance of two (2) foot of competent soil backing from the back of the guardrail posts is required with 6-foot long posts. For NCHRP-350 Systems, on a 6:1 or flatter slope, a minimum distance of one (1) foot of competent soil backing from the back of the guardrail posts is required with 6-foot long posts.

The soil backing should not be rated poorly for MASH and NCHRP-350 Strong Post W-Beam systems, since longer posts may be utilized when the required soil backing distance cannot be met.

Soil backing should be observed at adjacent posts where guardrail height measurements are taken. Additional observations of soil backing may be taken. When the minimum distance of competent soil backing is not met at 60% or more of observable sites, the guardrail run **shall** be found to not be in compliance. Alternately, engineering judgement may be applied to determine compliance.

A3.3 – Length of Need (LON)

The Length of Need (LON) is defined as the length of barrier needed upstream of traffic flowing in both directions on a two (2) lane roadway from the roadside hazard to prevent/shield vehicles from striking the existing hazard. The LON is determined from a geometric formula as outlined in Chapter 1 of the GRIT Manual and the AASHTO Roadside Design Guide.

When possible, calculations should be completed before the Field Scope Evaluation is performed as this distance is calculated by a geometric formula that is based on design speed, distance from the travel way to the back of hazard, and the offset of the barrier from the travel way. LON is independent of guardrail Functional Conditions Ratings; however, the LON **shall** be measured in the field, recorded, and entered in the VDOT GR Tracker as one of the following categories.

- LON is Met
- Field measured length is 5% shorter than calculated LON
- Field measured length is 10% shorter/ longer than calculated LON
- Field measured length is > 15% shorter/longer than calculated LON

IIM-TE-366.4 – Attachment A

Functional Conditions of Guardrail Systems

The Site Location Condition Evaluation thresholds **shall** also be evaluated in the field, recorded, and entered in the VDOT GR Tracker as one of the following categories defined in Section “A3 Site Location Condition Evaluation”.

- Meets current VDOT requirements (only when LON is met)
- Minor Improvement
- Moderate Improvement
- Major Improvement
- Not Feasible

Guardrail runs that are found to be either insufficient or in excess, should be modified by adding or removing guardrail and relocating terminal sections to more closely correspond to the required LON.

IIM-TE-366.4 – Attachment B

MASH W-Beam Guardrail System Evaluation

ATTACHMENT B: MASH W-Beam Guardrail System Evaluation

Section B1 – MASH W-Beam Guardrail System Standard Section

Table B1 provides a summary of the characteristics and requirements for MASH W-Beam guardrail system standard sections. The standard section **shall** be rated no higher than lowest Functional Condition as per the below table. Detailed guidance on each characteristic is provided in the referenced section of this policy in the rightmost column of the table.

Table B1 – General Criteria for MASH W-Beam Guardrail System Standard Sections

Characteristics Applicable to Standard Sections	Grade A	Grade B	Grade C	Grade D	Reference
GR-MGS1, GR-MGS1A					
Height of Rail	≥ 30" - ≤ 32"	≥ 29" - < 30" or > 32" - ≤ 33"	≥ 27" - < 29" or > 33" - ≤ 35"	< 27" or > 35"	IIM-TE-366.4 Attachment A & B and VDOT St'd GR-MGS1, GR-MGS1A
Rail Placed Between 2' and 12' From Shoulder, Slope Steeper Than 10:1	No			Yes	VDOT GRIT Manual
Double Nested Rail	No		Yes		
When Asphalt is Present	Posts installed behind asphalt or posts installed in 15" backfilled leave-outs			Posts installed in asphalt > 2" without leave-outs	
Fixed Object within Deflection Area	No			Yes	IIM-TE-366.4 Attachment A & B
Block-Outs are Present	12" block-outs or 16" block-outs as shown in the St'ds		> 16" block-outs used on more than 1 post within 100 LF		VDOT St'd GR-MGS1, GR-MGS1A, GR-MGS-INS
Block-Out Material	Composite or Wood		Steel		VDOT St'd GR-MGS1, GR-MGS1A, GR-MGS-INS
Washers Present at Rail Bolts	No		Yes		VDOT St'd MGS-HDW
Weathering Steel Present	No		Yes		I&IM-TE-366.4 Attachment A & B
When Curb is Present					
• <i>Design Speed > 45 mph</i>	4" curb and rail aligned w/ FOC		> 4" curb and/or rail is offset from curb		Appendix J of VDOT RDM
• <i>Design Speed ≤ 45 mph</i>	< 6" curb. Rail aligned w/ FOC or offset 6' min. from FOC.		> 6" curb and/or rail is offset < 6' from the FOC		Appendix J of VDOT RDM
Damage or Visible Defects	No		Yes		TE-367

IIM-TE-366.4 – Attachment B

MASH W-Beam Guardrail System Evaluation

Section B2 – MASH W-Beam Guardrail System End Treatments

Tables B2 and B3 provide a summary of the characteristics and requirements for MASH W-Beam guardrail system end treatments. The end treatment **shall** be rated no higher than lowest Functional Condition as per the below table. Detailed guidance on each characteristic is provided in the referenced section of this policy in the rightmost column of the table.

Table B2 – General Criteria for MASH W-Beam Guardrail System Run-On End Treatments

Characteristics Applicable to End Treatment	Grade A	Grade B	Grade C	Grade D	Reference
GR-MGS2					
Minimum Dimensions and Lengths for End Treatments Meet Standard	Yes		No		VDOT St'd GR-MGS2
Height of Rail	≥ 30" - ≤ 32"	≥ 29" - < 30" or > 32" - ≤ 33"	≥ 27" - < 29" or > 33" - ≤ 35"	< 27" or > 35"	IIM-TE-366.4 Attachment A & B and VDOT St'd GR-MGS2
Product is listed on the current VDOT MASH Approved List	Yes			No	
Fixed Object within Terminal Area	No			Yes	IIM-TE-366.4 Attachment A & B
Reflective Sheeting	Present and Good Condition	Not Present or Fair Condition			VDOT GR St'ds and GRIT Manual
Breakaway Posts Condition	Good	Fair	Poor	Not Present	
Cable Anchorage Condition	Good	Fair	Poor	Not Present	VDOT St'd GR-MGS2
Extruder Assembly (if applicable) Condition	Good	Fair	Poor		
Weathering Steel Present	No		Yes		IIM-TE-366.4 Attachment A & B
Curb Present*	Not present or meets curb offset layout				Appendix J of VDOT RDM
Damage or Visible Defects	No		Yes		TE-367

* Contact Central Office Traffic Engineering Division for additional guidance if curb is present that does not meet the curb offset layout.

IIM-TE-366.4 – Attachment B

MASH W-Beam Guardrail System Evaluation

Table B3 – General Criteria for MASH W-Beam Guardrail System Run-Off End Treatments

Characteristics Applicable to End Treatment	Grade A	Grade B	Grade C	Grade D	Reference
GR-MGS3					
Minimum Dimensions and Lengths for End Treatments Meet Standard	Yes		No		VDOT GRIT Manual, VDOT St'ds
Height of Rail	$\geq 30"$ - $\leq 32"$	$\geq 29"$ - $< 30"$ or $> 32"$ - $\leq 33"$	$\geq 27"$ - $< 29"$ or $> 33"$ - $\leq 35"$	$< 27"$ or $> 35"$	IIM-TE-366.4 Attachment A & B and VDOT St'd GR-MGS3
Fixed Object within Deflection Area	No			Yes	IIM-TE-366.4 Attachment A & B
Cable Anchorage Condition	Good	Fair	Poor	Not Present	VDOT St'd GR-MGS3
Weathering Steel Present	No		Yes		IIM-TE-366.4 Attachment A & B
When Curb is Present					
<ul style="list-style-type: none"> <i>Design Speed > 45 mph</i> 	4" curb and rail aligned w/ FOC		> 4" curb and/or rail is offset from curb		Appendix J of VDOT RDM
<ul style="list-style-type: none"> <i>Design Speed \leq 45 mph</i> 	<6" curb. Rail aligned w/ FOC or offset 6' min. from FOC.		> 6" curb and/or rail is offset <6' from the FOC		Appendix J of VDOT RDM
Damage or Visible Defects	No		Yes		TE-367

ATTACHMENT C: NCHRP-350 Guardrail System Evaluation

Section C1 – NCHRP-350 Guardrail System Standard Sections

Table C1 provides a summary of the characteristics and requirements for NCHRP-350 guardrail system standard sections. The standard section **shall** be rated no higher than lowest Functional Condition as per the below table. Detailed guidance on each characteristic is provided in the referenced section of this policy in the rightmost column of the table.

Table C1 – General Criteria for NCHRP-350 Guardrail System Standard Sections

Characteristics Applicable to Standard Section	Grade A	Grade B	Grade C	Grade D	Reference
All NCHRP-350 Standard Guardrail Systems					
Weathering Steel Present	No		Yes		IIM-TE-366.4 Attachment A & C
Damage or Visible Defects	No		Yes		TE-367
GR-2, GR-2A, MB-3					
Height of Rail	$\geq 27\frac{3}{4}" - \leq 28\frac{3}{4}"$	$\geq 27" - < 27\frac{3}{4}"$ or $> 28\frac{3}{4}" - \leq 30"$	$\geq 24" - < 27"$ or $> 30" - \geq 33"$	$< 24"$ or $> 33"$	IIM-TE-366.4 Attachment A & C and VDOT St'd GR-2, GR-2A
Rail Placed Between 2' and 12' From Shoulder, Slope Steeper Than 10:1	No			Yes	VDOT GRIT Manual
Block-Outs are Present			Triple block-outs used on more than one post or more than 3 block-outs used on any posts		VDOT GRIT Manual, VDOT St'd GR-2, GR-2A
Wood Block-Outs	As shown in the Standards, wood block-outs toe-nailed on both sides	Wood block-outs are only toe-nailed on one side			VDOT GRIT Manual, VDOT St'd GR-2, GR-2A
Block-Out Material	Composite or Wood		Steel		VDOT GRIT Manual, VDOT St'd GR-2, GR-2A
Washers Present at Rail Bolts	No		Yes		VDOT St'd GR-HDW

IIM-TE-366.4 – Attachment C

NCHRP-350 Guardrail System Evaluation

**Table C1 – General Criteria for NCHRP-350 Guardrail System Standard Sections
(continued)**

Characteristics Applicable to Standard Section	Grade A	Grade B	Grade C	Grade D	Reference
When Curb is Present					
<ul style="list-style-type: none"> <i>Design Speed ≤ 45 mph</i> 	4" mountable curb and rail aligned w/ FOC or 6" vertical curb and rail offset 8' min. from FOC		> 4" mountable curb	Any vertical curb and rail is not offset 8' min from FOC	Appendix I of VDOT RDM
<ul style="list-style-type: none"> <i>Design Speed > 45 mph</i> 	GR-2A used w/ 4" mountable curb and rail aligned w/ FOC	Stiffened GR-2 used w/ 4" mountable curb and rail aligned w/ FOC	GR-2 (not stiffened) used w/ 4" mountable curb and rail aligned w/ FOC	> 4" mountable curb or any vertical curb	Appendix I of VDOT RDM
GR-8, GR-8A, GR-8B, GR-8C, MB-5					
Height of Rail	≥ 31 ½" - ≤ 33"	≥ 31" - < 31½" or > 33" - ≤ 34"	≥ 29" - < 31" or > 34" - ≤ 36"	< 29" or > 36"	I&IM-TE-366.4 Attachment A & C and VDOT St'd GR-8
<ul style="list-style-type: none"> Block-Outs are Present 	No		Yes		VDOT GRIT Manual, VDOT St'd GR-8
<ul style="list-style-type: none"> Back-up Plates at Non-Splice Locations 	Yes		No		VDOT GRIT Manual
Rail Splice Located Between Posts	Yes			No	VDOT GRIT Manual, VDOT St'd GR-8
Washers Present at Rail Bolts	Yes		No		VDOT GRIT Manual, VDOT St'd GR-8
Soil Backing	≥ 1' soil behind posts			< 1' soil behind posts due to erosion	VDOT GRIT Manual
Curb Present	Not present			Yes	VDOT St'd GR-INS
GR-3					
GR-3 Height of Cable	≥ 27" - ≤ 28"	≥ 26" - < 27" or > 28" - ≤ 29"	≥ 24" - < 26" or > 29" - ≤ 31"	< 24" or > 31"	I&IM-TE-366.4 Attachment A & C and VDOT St'd GR-3
Soil Backing	≥ 1' soil behind posts			< 1' soil behind posts due to erosion	VDOT GRIT Manual

Section C2 –NCHRP-350 Guardrail System End Treatments

Tables C2 and C3 provide a summary of the characteristics and requirements for NCHRP-350 guardrail system end treatments. The end treatments **shall** be rated no higher than lowest Functional Condition as per the below table. Detailed guidance on each characteristic is provided in the referenced section of this policy in the rightmost column of the table.

IIM-TE-366.4 – Attachment C

NCHRP-350 Guardrail System Evaluation

Table C2 – General Criteria for General Criteria for NCHRP-350 Guardrail Run-On End Treatments

Characteristics Applicable to End Treatment	Grade A	Grade B	Grade C	Grade D	Reference
All NCHRP-350 Run-On End Treatment Guardrail Systems					
Minimum Dimensions and Lengths for End Treatments Meet Standard	Yes		No		VDOT GRIT Manual, VDOT St'ds
End Treatment Does Not Meet NCHRP-350 Requirements (e.g., blunt ends, MELT, turndown, etc.)	No			Yes	VDOT GRIT Manual
Fixed Object within Terminal Area	No			Yes	IIM-TE-366.4 Attachment A & B
Weathering Steel Present	No		Yes		I&IM-TE-366.4 Attachment A & B
Soil Backing	≥ 1' soil behind posts			< 1' soil behind posts due to erosion	VDOT GRIT Manual
Curb Present*	Not present or meets curb offset layout				Appendix I of VDOT RDM
Damage or Visible Defects	No		Yes		TE-367
GR-6					
Height of Rail	≥ 27 ³ / ₄ " - ≤ 28 ³ / ₄ "	≥ 27" - < 27 ³ / ₄ " or > 28 ³ / ₄ " - ≤ 30"	≥ 24" - < 27" or > 30" - ≥ 33"	< 24" or > 33"	I&IM-TE-366.4 Attachment A & C and VDOT St'd GR-6
Site Preparation Meets Requirements of GR-6	Yes	No (Refer to AASHTO Roadside Design Guide flex statement)			VDOT GRIT Manual and VDOT St'd GR-6
Number of Rail Elements Meets Standard	Yes		No		VDOT St'd GR-6
Anchorage Buried and Not Exposed	Yes, unless bolted to rock face		No		VDOT St'd GR-6
Adequacy of Back Slope Meets Standard	Yes		No		VDOT St'd GR-6

* Contact Central Office Traffic Engineering Division for additional guidance if curb is present that does not meet the curb offset layout.

**IIM-TE-366.4 – Attachment C
NCHRP-350 Guardrail System Evaluation**

Table C2 – General Criteria for NCHRP-350 Guardrail Run-On End Treatments (continued)

Characteristics Applicable to End Treatment	Grade A	Grade B	Grade C	Grade D	Reference
GR-7					
Height of Rail	$\geq 27\frac{3}{4}" - \leq 28\frac{3}{4}"$	$\geq 27" - < 27\frac{3}{4}"$ or $> 28\frac{3}{4}" - \leq 30"$	$\geq 24" - < 27"$ or $> 30" - \geq 33"$	$< 24"$ or $> 33"$	I&IM-TE-366.4 Attachment A & C and VDOT St'd GR-7
Product is listed on the current VDOT NCHRP-350 Approved List	Yes			No	
Reflective Sheeting	Present and Good Condition	Not Present or Fair Condition			VDOT GR St'ds and GRIT Manual
Breakaway Posts Condition	Good	Fair	Poor	Not Present	
Cable Anchorage Condition	Good	Fair	Poor	Not Present	VDOT St'd GR-7
Extruder Assembly (if applicable) Condition	Good	Fair	Poor		
GR-9					
Height of Rail	$\geq 27\frac{3}{4}" - \leq 28\frac{3}{4}"$	$\geq 27" - < 27\frac{3}{4}"$ or $> 28\frac{3}{4}" - \leq 30"$	$\geq 24" - < 27"$ or $> 30" - \geq 33"$	$< 24"$ or $> 33"$	I&IM-TE-366.4 Attachment A & C and VDOT St'd GR-9
Product is listed on the current VDOT NCHRP-350 Approved List	Yes			No	
Reflective Sheeting	Present and Good Condition	Not Present or Fair Condition			VDOT GR St'ds and GRIT Manual
Breakaway Posts Condition	Good	Fair	Poor	Not Present	
Cable Anchorage Condition	Good	Fair	Poor	Not Present	VDOT St'd GR-9
Extruder Assembly Condition	Good	Fair	Poor		
GR-3					
Location and Type of First Post Meets Current Standard	Yes		No		VDOT St'd GR-3

IIM-TE-366.4 – Attachment C

NCHRP-350 Guardrail System Evaluation

Table C3 – General Criteria for General Criteria for NCHRP-350 Guardrail Run-Off End Treatments

Characteristics Applicable to End Treatment	Grade A	Grade B	Grade C	Grade D	Reference
All NCHRP-350 Run-Off Treatment Guardrail Systems					
Minimum Dimensions and Lengths for End Treatments Meet Standard	Yes		No		VDOT GRIT Manual, VDOT St'ds
End Treatment Does Not Meet NCHRP-350 Requirements (e.g., blunt ends, MELT, turndown, etc.)	No			Yes	VDOT GRIT Manual
Fixed Object within Terminal Area	No			Yes	IIM-TE-366.4 Attachment A & B
Weathering Steel Present	No		Yes		I&IM-TE-366.4 Attachment A & B
Longitudinal Guardrail as Anchorage (Washers Present at End Assembly)	No		Yes		VDOT St'd GR-HDW
Soil Backing	≥ 1' soil behind posts			< 1' soil behind posts due to erosion	VDOT GRIT Manual
Damage or Visible Defects	No		Yes		TE-367
GR-11					
Height of Rail	≥ 27 ³ / ₄ " - ≤ 28 ³ / ₄ "	≥ 27" - < 27 ³ / ₄ " or > 28 ³ / ₄ " - ≤ 30"	≥ 24" - < 27" or > 30" - ≥ 33"	< 24" or > 33"	I&IM-TE-366.4 Attachment A & C and VDOT St'd GR-11
Cable Anchorage Condition	Good	Fair	Poor	Not Present	VDOT St'd GR-11
When Curb is Present					
<ul style="list-style-type: none"> Design Speed ≤ 45 mph 	4" mountable curb and rail aligned w/ FOC or 6" vertical curb and rail offset 8' min. from FOC		> 4" mountable curb	Any vertical curb and rail is not offset 8' min from FOC	VDOT GRIT Manual
<ul style="list-style-type: none"> Design Speed > 45 mph 	GR-2A used w/ 4" mountable curb and rail aligned w/ FOC	Stiffened GR-2 used w/ 4" mountable curb and rail aligned w/ FOC	GR-2 (not stiffened) used w/ 4" mountable curb and rail aligned w/ FOC	> 4" mountable curb or any vertical curb	VDOT GRIT Manual

ATTACHMENT D: Upgrade Strategies for Substandard Guardrail

When feasible and appropriate, MASH systems should be installed in place of existing **substandard** NHCPR-350 systems. The following sections provide guidance that users should consider when determining site-specific improvements. The strategies below are provided based on the current VDOT MASH approved products available at the time of this publication. New MASH systems should be considered when they become available and are appropriate.

Section D1 – Upgrade Strategies for MASH Systems

D1.1 Standard Sections

Standard GR-MGS1

- When an existing GR-MGS1 needs to be upgraded, it should be replaced with a Standard GR-MGS1.

D1.2 End Treatments

Standard GR-MGS2

- When an existing GR-MGS2 needs to be upgraded, it should be replaced with a Standard GR-MGS2.

Standard GR-MGS3

- When an existing GR-MGS3 needs to be upgraded, it should be replaced with a Standard GR-MGS3

Section D2 – Upgrade Strategies for NCHRP-350 Systems

D2.1 Standard Sections

Standard GR-1

All Standard GR-1 guardrail should be identified on all roadway systems and replacement schedules should be set so that appropriate funding can be budgeted for upgrades. Existing Standard GR-1 guardrail systems installed on any roadway within the National Highway System (NHS) **shall** receive first priority for upgrading as soon as possible.

- Existing Standard GR-1 guardrail systems should be replaced with a Standard GR-MGS1 (or other MASH system equivalent to Standard GR-1).

Standard GR-2

When an existing Standard GR-2 needs to be upgraded, it should be replaced with a Standard GR-MGS1 (or other MASH system equivalent to Standard GR-2). If a portion of existing Standard GR-2 is left in place, Standard GR-MGS4 **shall** be used to transition from existing Standard GR-2 to new Standard GR-MGS1.

Standard GR-3

When an existing GR-3 needs to be upgraded, it should be replaced with a Standard GR-MGS1 (or other MASH system equivalent to Standard GR-3).

Standard GR-8

For any existing GR-8 guardrail adjacent to curb:

- The curb **shall** be removed.
- If the curb cannot be removed the GR-8 **shall** be upgraded to GR-MGS1 standard, or other MASH system equivalent to Standard GR-MGS1.

When an existing Standard GR-8 needs to be upgraded, it should be replaced with a Standard GR-MGS1, or other MASH system equivalent to Standard GR-8.

Proprietary High Tension

When an existing proprietary high-tension system needs to be upgraded, it should be replaced with the appropriate MASH system meeting current standards.

D2.2 End Treatments

Standard GR-3 Anchorage

When an existing GR-3 anchorage needs to be upgraded, it should be replaced with the appropriate terminal treatment meeting current standards.

Standard GR-5

All existing GR-5 turn-down terminals **shall** be removed and replaced with the appropriate terminal treatment meeting current standards:

- When an existing GR-5 terminal is in place at run-on locations on any NHS roadway, it **shall** be prioritized for replacement in consideration of identified needs and available funding.
- All other GR-5 terminals on non-NHS roadways **shall** be scheduled for upgrading per scheduling guidelines.

Standard GR-6

A site investigation **shall** be made to determine whether the existing GR-6 terminal should be upgraded:

- If the installation site does not provide at least 75' of clear run-out path from the cut/fill break to where the guardrail crosses the ditch, a Standard GR-MGS2 terminal (or other MASH system) should be installed.
- When an existing GR-6 needs to be upgraded, it should be replaced with a Standard GR-6.

Standard GR-7

A site investigation **shall** be made to determine whether the existing GR-7 terminal should be upgraded or eliminated:

- If there is a cut slope within approximately 200' longitudinal distance from the location of an existing GR-7 terminal, the guardrail **shall** be extended to the cut slope and a Standard GR-6 terminal installed.
- If the space between two runs of guardrail is < 200', closing the gap by continuing the run of guardrail is recommended, thereby eliminating the need for a terminal.
- If the existing GR-7 is not on the current approved product list and/or when replacing an existing GR-7 terminal in the same location, it should be replaced with a Standard GR-MGS2 terminal (or other MASH system equivalent to Standard GR-7).

Standard GR-9

A site investigation **shall** be made to determine whether the existing GR-9 terminal should be upgraded or eliminated:

- If there is a cut slope within approximately 200' longitudinally of the location of an existing GR-9 terminal, the guardrail **shall** be extended to the cut slope and a Standard GR-6 terminal installed.
- If the space between two runs of guardrail is < 200', closing the gap by continuing the run of guardrail is recommended, thereby eliminating the need for a terminal.
- If the existing GR-9 is not on the current approved product list and/or when replacing an existing GR-9 terminal in the same location, it should be upgraded to GR-MGS2 terminal (or other MASH system equivalent to Standard GR-9).

Standard GR-11

When an existing GR-11 needs to be upgraded, it should be replaced with a Standard GR-MGS3 (or other MASH system) if attached to GR-MGS1, or with a new GR-11 if attached to GR-2

Additional Longitudinal Guardrail as End Anchorage

The trailing end section (last 50 feet) of any longitudinal GR-2 guardrail with rectangular washers on divided highways should be replaced with a Standard GR-MGS3 (or other MASH system).

Radial Guardrail

All radial guardrail used as an end treatment (including at driveways and private entrances) **shall** be replaced with either a Standard GR-MGS2 or Standard GR-MGS3, as appropriate (or other MASH system).

Proprietary High Tension

When an existing proprietary high-tension end treatment needs to be upgraded, it should be replaced with the appropriate terminal treatment meeting current standards.